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# DEFECT IN DOUGLAS-FIR AND GRAND FIR TOP-KILLED BY THE DOUGLAS-FIR TUSSOCK MOTH

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## INTRODUCTION

Tree defoliation caused by the Douglas-fir tussock moth, *Orgyia pseudotsugata* McD, was detected in 1963 near Burns, Oregon. By the fall of 1964, the insect killed 2.6 million board feet of mature and immature Douglas-fir, *Pseudotsuga menziesii*, and true fir, *Abies* spp., on 1,950 acres in the Malheur and Ochoco National Forests. During June 1965, 66,000 acres of infested forest were sprayed with DDT to control the insect (Perkins and Dolph, 1967).

Dieback of tree tops commonly occurred where defoliation was not severe enough to kill the entire tree (Figure 1 and 2). Subsequently, many of the top-killed trees developed new leaders resulting in multiple-topped or deformed trees.

Several studies have been made in the past to determine the extent of deterioration of conifers following defoliation by insects (Engelhardt, 1957; Johnson, et.al., 1970; Stillwell, 1956; Wickman, 1963; Wickman and Scharpf, 1972). Engelhardt (1957) found that decay and breakage of western hemlock, *Tsuga heterophylla*, which died after being defoliated by the western hemlock looper, *Lambdina fiscellaria lugubrosa*, in British Columbia increased progressively from year of tree death. After 7 years, all dead trees were cull due to saprot. *Fomes pinicola* was responsible for most of the defect noted.

Stillwell (1956) during his investigations on deterioration of balsam fir, *Abies balsamea*, damaged by spruce budworm, *Choristoneura fumiferana*, in New Brunswick, Canada, found a high incidence of decay in top-killed trees, but the extent of decay was variable.

Studies of mortality, growth reduction, and degrade of white fir, *Abies concolor*, in California after defoliation by the tussock moth have been published (Wickman, 1963; Wickman and Scharpf, 1972). Wickman and Scharpf (1972) found very little

defect other than a condition known as "wetwood" associated with trees top-killed approximately 33 years prior to the study. No information is available on the amount of defect associated with top-killing by the Douglas-fir tussock moth in the Pacific Northwest.

The purpose of this study was to determine the extent of defect associated with trees top-killed by tussock moth during the 1963-65 outbreak in eastern Oregon. This information will be useful to the land manager in the scheduling and selection of damaged trees for harvest following tussock moth outbreaks.

## STUDY AREA AND METHODS

Two sites in the vicinity of King Mountain on the Malheur National Forest were selected for study. Douglas-firs and grand firs, *Abies grandis*, exhibiting spike, bayonet, forked, or multiple tops were felled (Figure 2). Trees exhibiting obvious mechanical or porcupine-feeding injuries were discarded. To determine if the damage resulted from defoliation by tussock moth, a cross sectional cut was made at the junction of the dead top and live leader according to the procedures outlined by Stillwell (1956) and Wickman and Scharpf (1972) (Figure 3). Leaders on trees damaged by the tussock moth were killed during 1965 to 1968. If the cause of top kill was attributed to tussock moth defoliation, the main stem was sectioned at 1-foot intervals to measure the extent of discoloration and decay below the base of the dead top (Figure 4).

## ISOLATION OF ORGANISMS FROM TOP-KILLED TREES

To identify the organisms associated with discoloration and decay in the study trees, selected wood discs (1 to 2 inches thick) were cut, placed in polyethylene bags, and stored in ice chests in the field. Discs were stored no longer than 5 days in this manner before they were placed in a walk-in cooler at 4 degrees C.

Two types of agar media were used for isolation of organisms from the discs.

1. 2 percent malt agar (MA) medium (20 g. Difco bacto-agar; 10 g. malt extract; 2 g. yeast extract in 1000 ml of distilled water).

2. 2 percent malt agar medium supplemented with 100 ppm streptomycin sulfate (MAS) (Wickman and Scharpf, 1972).

Autoclaved media were dispensed into plastic petri plates (15 x 100 mm). Sample wood discs were washed twice in 0.5

percent sodium hypochlorite (chlorox) solution. Discs were then split. One-half of each split disc was immersed for 15 minutes in 0.1 percent chlorox solution and rinsed in sterile distilled water. Ten wood chips were removed from the split face of the surface-sterilized disc using aseptic techniques. Chips were taken from apparently defect-free wood, "wetwood," and incipient decay. Five chips were placed on MA media, five on MAS media. Plates were incubated for 2 to 3 weeks at room temperature (24-25 degrees C.). During the period of incubation, fungi growing from the chips were subcultured and grown in pure culture on MA media for identification.

## RESULTS AND DISCUSSION

A total of 7 Douglas-firs and 9 grand firs were felled and dissected in this study. The Douglas-firs ranged in size from 7 to 22 inches dbh (average 12 inches); grand firs were 10 to 15 inches dbh (average 13 inches) (Tables 1 and 2). Additional data collected for each tree are presented in Tables 1 and 2.

At times, it was difficult to differentiate damage resulting from insect defoliation and that due to other factors. Defect columns associated with broken branches and wounds below the dead tops were noted for both tree species (Tables 1 and 2). For the calculation of average visible defect and decay for each species, trees with confounding injuries were omitted.

Douglas-fir differed from grand fir in extent of discoloration and decay. Visible defect (noted primarily as discoloration of the wood) was apparent in only two of the Douglas-firs; whereas, all the grand firs exhibited defect. The extent of defect was also greater for the grand firs (Tables 1 and 2). A possible explanation for the greater amount of visible defect in the grand firs is that this species suffered more initial top damage from defoliation than did the Douglas-firs. The data in Tables 1 and 2 show that the average length and diameter of the dead tops of the grand firs were greater than for the Douglas-firs. Very little decay was noted in either species (Tables 1 and 2).

Isolations from damaged trees yielded several organisms, none of which are known to cause decay (Table 3). None of the trees bore sporophores of any decay fungus. Maloy and Robinson (1968) also were unsuccessful in isolating decay organisms from grand firs lacking sporophores despite the fact that many trees appeared decayed.

In this study, the most commonly isolated organisms were woodstaining fungi and bacteria (Table 3). *Aureobasidium pullulans* and *Trichoderma* sp. were the most frequently isolated fungi. Bacteria have been reported by other workers as associated with a condition called "wetwood" in true firs (Maloy and Robinson, 1968; Wickman and Scharpf, 1972). A study by Wilcox and Pong (1971) indicates that wetwood has little or no detrimental effect on white fir wood properties, other than increasing drying time in the kiln.

Past studies indicate that there is a succession of bacteria and fungi which predispose wood to invasion by decay fungi. Where a succession could be postulated, the bacteria and non-hymenomycetes invaded first followed by basidiomycetes (Shigo, 1967).

The common occurrence of wetwood in Douglas-fir tussock moth defoliated trees is not fully understood, but this condition was reported in other studies of insect damaged trees (Wickman and Scharpf, 1972). It is possible that a succession of organisms is also involved in the deterioration of insect-defoliated trees. During 1972 to 1974, one of the largest recorded infestations of Douglas-fir tussock moth occurred in the Pacific Northwest. Since defoliation by the tussock moth can result in up to 33 percent of the stand being top-killed (Mounts, et. al., 1973), additional studies are warranted to follow the progress of defect development over several years and define the interaction of organisms in damaged trees.

## CONCLUSIONS AND RECOMMENDATIONS

Examination in 1974 of felled Douglas-firs and grand firs top-killed by the Douglas-fir tussock moth during the 1963-1965, Burns, Oregon, outbreak, showed grand fir had more visible defect than Douglas-fir. Decay was minimal in both species. Because of the greater susceptibility of true firs to damage, salvage of the top-killed true firs should receive priority over Douglas-firs.

## ACKNOWLEDGMENTS

Grateful acknowledgment is expressed to Messrs. Lloyd Fuller and Thomas Altenreuther, Oregon State University, for assistance in the field and laboratory work and to Dr. Michael J. Larsen, Botanist, Center for Mycology Research, Forest Products Laboratory, Madison, Wisconsin for assistance in the identification of cultures.

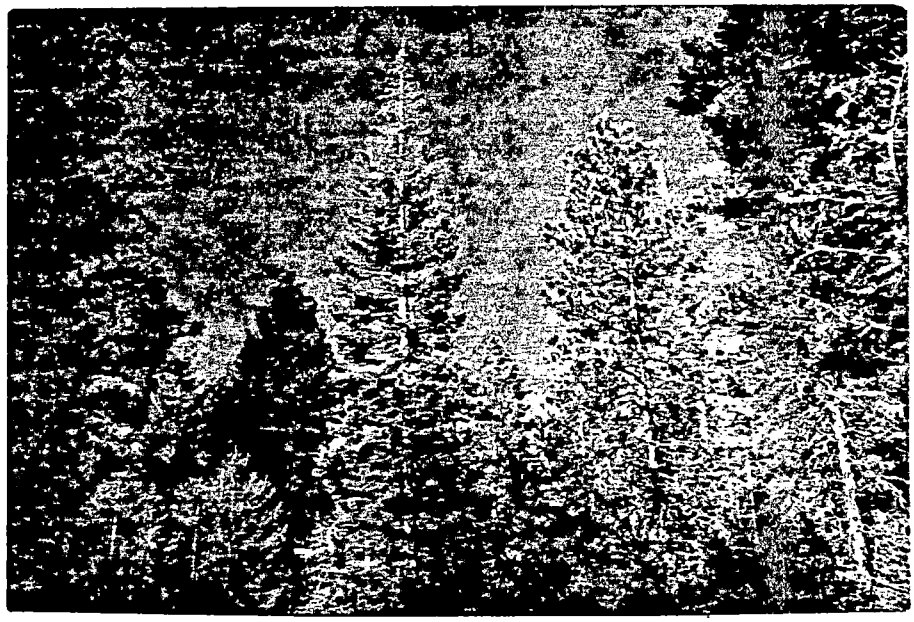

Figure 1. Defoliation of true firs and Douglas-firs by Douglas-fir tussock moth, King Mountain, Malheur National Forest, Oregon.

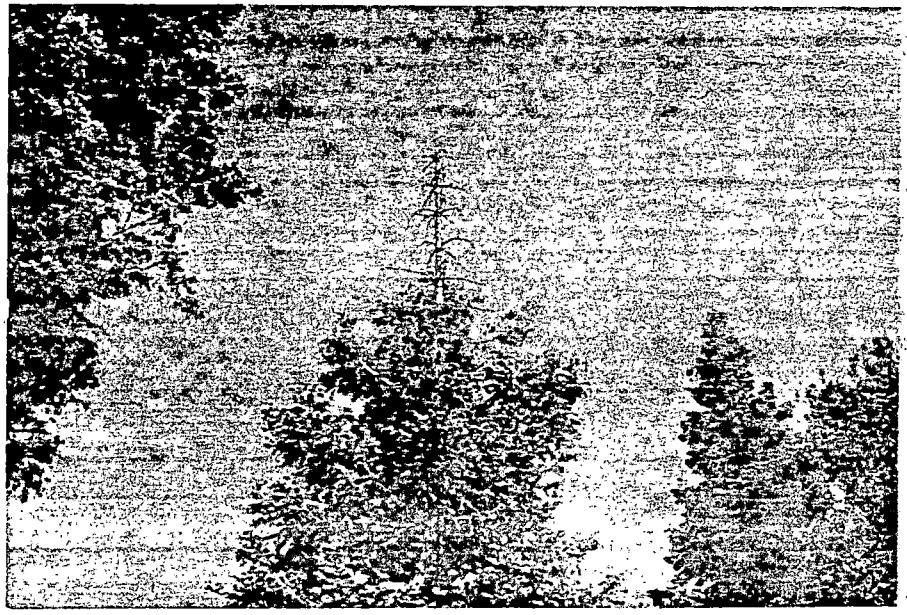

Figure 2. Douglas-fir top-killed by the Douglas-fir tussock moth during the 1963-65 outbreak.

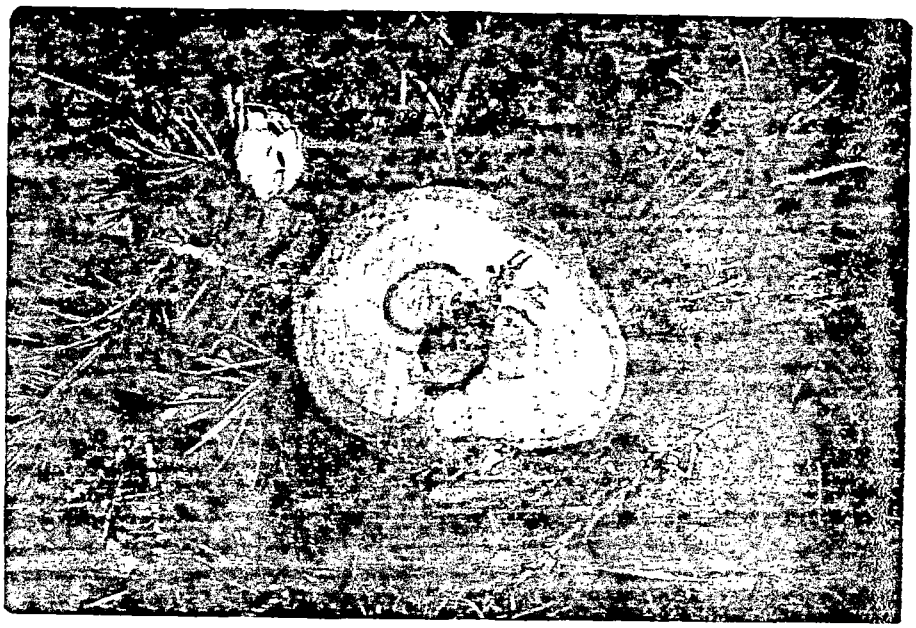

Figure 3. Cross-section of a top-killed Douglas-fir. The section was made at the base of the dead leader to determine the year of death.

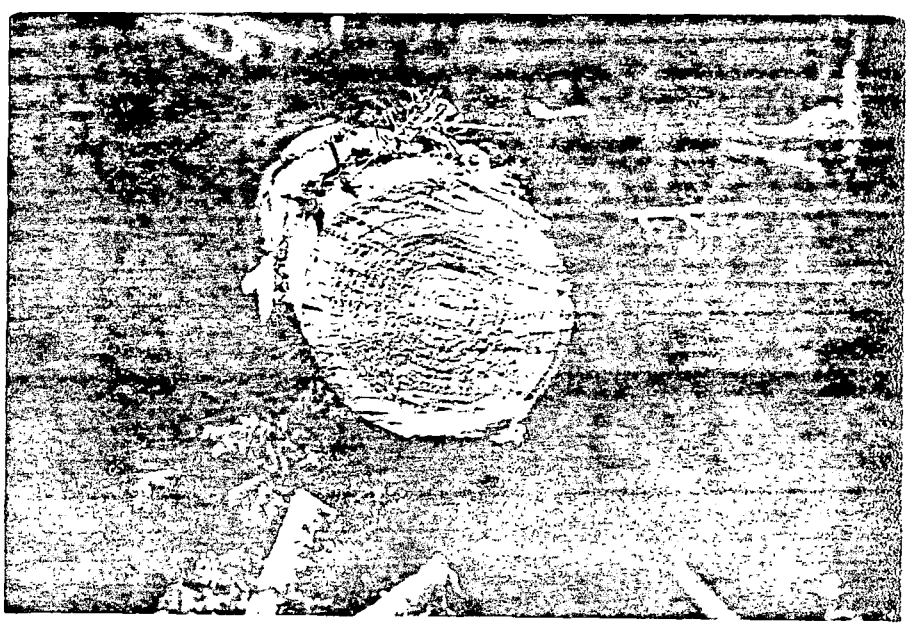

Figure 4. Cross-section of a top-killed Douglas-fir. The main stem was sectioned at one-foot intervals to determine the extent of discoloration and decay below the base of the dead top.

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Table 1.--Top damage to Douglas-firs resulting from Douglas-fir tussock moth defoliation during 1963-1965, near King Mountain, Oregon

| Tree Number | D.B.H. (inches) | Age at stump (1 foot high) | Total Height (feet) | Length of new leader (feet) | Dead Leader | | | | Longitudinal extent of wet wood or decay below base of dead leader (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Length (feet) | Diameter (inches) | Age (years) | Year of Death | |
| 1 | 14.6 | 79 | 63 | 4.2 | 5.5 | 3.6 | 13+ | 1966 | Decay 12 feet; visible defect 24 feet |
| 2 | 7.4 | 58 | 33 | 7.0 | 2.5 | 1.0 | 7 | 1966 | 1/Visible defect 4 feet |
| 3 | 9.8 | 64 | 47 | 5.8 | 4.6 | 1.6 | 9 | 1966 | No visible defect |
| 4 | 8.4 | 39 | 42 | 8.8<br>9.5 | --- | 0.5 | 2 | 1967 | No visible defect |
| 5 | 21.7 | 124 | 85 | --- | 22.0 | 7.0 | 29 | 1967 | No visible defect |
| 6 | 7.7 | 56 | 37 | 4.9 | 1.0 | 1.0 | 6 | 1966 | No visible defect |
| 7 | 14.2 | 80 | 75 | 9.0<br>7.0 | 5.2 | 1.8 | 8 | 1967 | No visible defect |
| Average | 11.9 | 71 | 54.6 | 7.0 | 6.8 | 2.3 | 11 | 1966-1967 | Visible defect 4.0 feet<br>Decay 2.0 feet |

1/ Encountered additional wounds below damaged top. In the calculation of average defect and decay, these values were omitted.

Table 2.--Top damage to grand firs resulting from Douglas-fir tussock moth defoliation during 1963-1965, near King Mountain, Oregon

| Tree Number | D.B.H. (inches) | Age at stump (1 foot high) | Total Height (feet) | Length of new leader (feet) | Dead Leader | | | | Longitudinal extent of wet wood or decay below base of dead leader (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Length (feet) | Diameter (inches) | Age (years) | Year of Death | |
| 1 | 11.9 | 73 | 27 | 8.0<br>5.0<br>6.5 | -- | 6.8 | 27 | 1966 | Visible defect 6 feet |
| 2 | 10.5 | 62 | 45 | --- | 6.5 | 3.5 | -- | 1965 | 1/ Decay at least 8 feet |
| 3 | 15.1 | 64 | 56 | 2.5 | 12.6 | 3.8 | 13 | 1967 | 1/ Visible defect 3 feet |
| 4 | 11.0 | 80 | 46 | 7.5<br>6.5 | 3.0 | 1.5 | 10 | 1966 | Visible defect 1 foot |
| 5 | 13.6 | 64 | 46 | 5.2 | --- | 2.5 | 8 | 1966 | Visible defect 2 feet |
| 6 | 15.2 | 88 | 62 | --- | 14.1 | 4.2 | 18 | 1967 | Visible defect 4 feet |
| 7 | 10.2 | 79 | 51 | --- | 4.0 | 4.0 | 7 | 1967 | Visible defect 2 feet |
| 8 | 14.3 | 78 | 56 | 7.6<br>4.9 | 16.9 | 4.8 | 14 | 1968 | Visible defect 6 feet |
| 9 | 13.6 | 78 | 63 | --- | 13.0 | 6.8 | 21 | 1967 | Decay 3 feet<br>Visible defect 32 feet |
| Average | 12.8 | 74 | 50.2 | 5.9 | 10.0 | 4.2 | 15 | 1965-1968 | Visible defect 7.6 feet<br>Decay 0.4 feet |

1/ Encountered additional wounds below damaged top. In the calculation of average defect and decay, these values were omitted.

TABLE 3.--Occurrence of microorganisms in Douglas-firs and grand firs topkilled by the Douglas-fir tussock moth

| Tree Species | Douglas-fir | | Grand fir | |
|---|---|---|---|---|
| Number of trees studied | 7 | | 9 | |
| Isolation medium[1/] | MA | MAS | MA | MAS |
| Number of wood chips plated | 70 | 75 | 125 | 125 |
| Percentage of chips yielding the following organism: | | | | |
| Bacteria | 94.3 | 58.7 | 84.0 | 34.4 |
| Imperfect fungi | | | | |
| *Aspergillus* sp. | 0 | 0 | 0 | 1.0 |
| *Aureobasidium pullulans* | 42.9 | 32.0 | 12.8 | 25.6 |
| *Cytospora* sp. | 2.9 | 1.3 | 3.2 | 1.6 |
| *Fusarium* sp. | 1.4 | 2.9 | 4.0 | 8.0 |
| *Geotrichum* sp. | 0 | 0 | 2.4 | 3.2 |
| *Graphium* sp. | 0 | 0 | 0 | 1.6 |
| *Mucor* sp. | 0 | 0 | 3.2 | 4.0 |
| *Penicillium* sp. | 1.4 | 0 | 0 | 2.4 |
| *Trichoderma* sp. | 7.1 | 41.3 | 20.0 | 26.4 |
| Unidentified | 10.0 | 13.3 | 19.2 | 16.0 |

1/ MA = malt agar medium; MAS = malt agar medium supplemented with 100 ppm streptomycin sulfate.